U. S. FOREST SERVICE

RESEARCH NOTE NC-46

NORTH CENTRAL FOREST EXPERIMENT STATION, FOREST SERVICE—U.S. DEPARTMENT OF AGRICULTURE

Folwell Avenue, St. Paul, Minnesota 55101

Use Hardwoods for Building Components

ABSTRACT.—Describes a system for prefabricating structural units from hardwoods for use in floors, roofs, and walls of A-frame or post-and-beam type construction. The interior face of the unit is decorative paneling; the exterior face is sheathing. Use of the system could reduce prefabricated house construction costs compared to conventional construction costs.

In recent years factory-built houses and house construction components have gained popularity because of on-site construction speed and lower costs. Most are made from softwood construction lumber and plywood, softwood laminated beams and decking, and softwood siding.

In the eastern hardwood regions of the United States the question has been asked: "Can local hardwood lumber be used for prefabricated building components?" To answer this question the North Central Forest Experiment Station at Carbondale, Illinois, and the Forest Products Technology Department at the Vocational Technical Institute of Southern Illinois University designed and built prefabricated red oak combination roof-floor-wall units for a 24- by 36-foot A-frame house.

Design

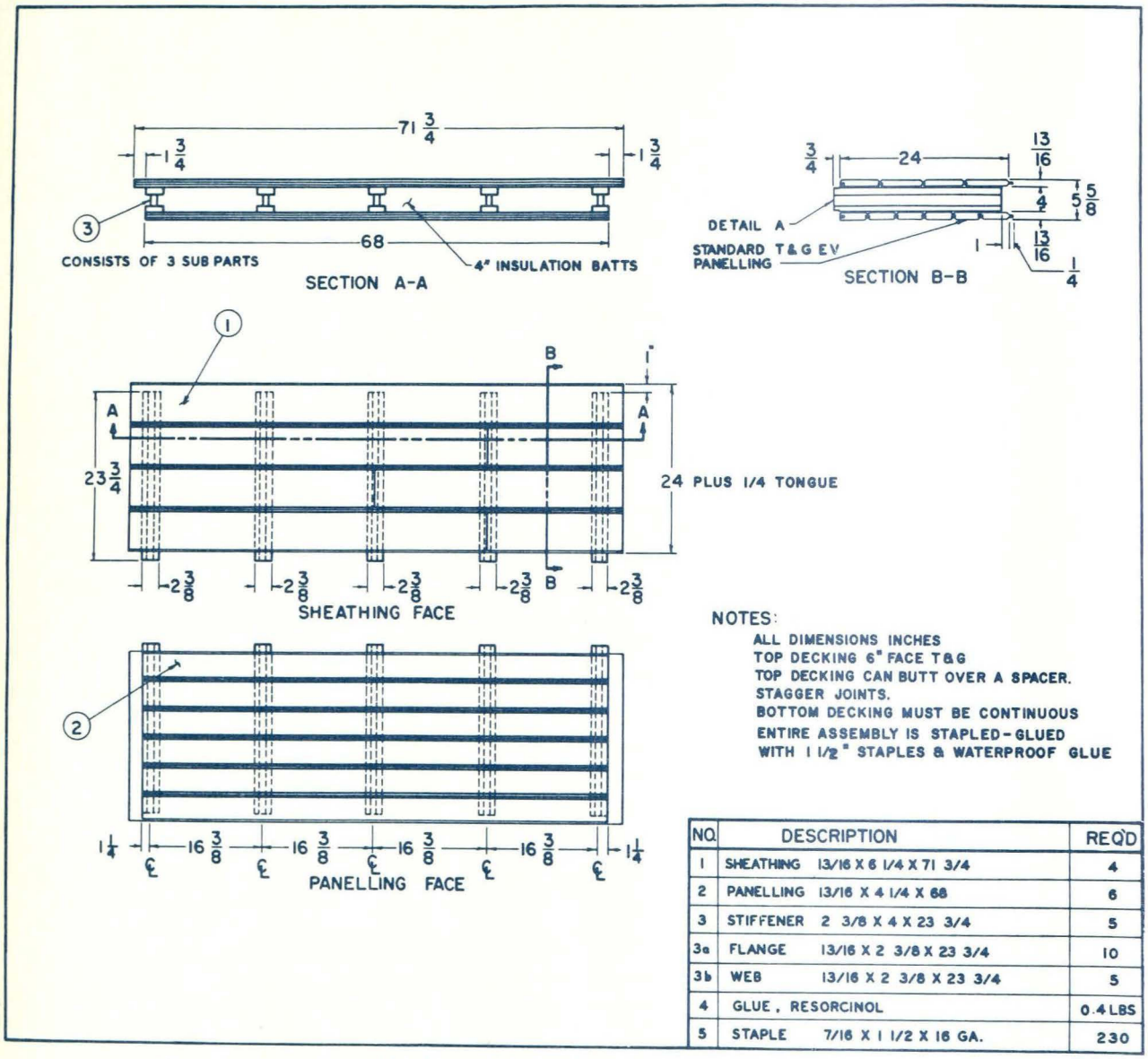
We chose red oak to utilize its strength for exterior sheathing and subflooring and its beauty for interior paneling. Several test units were made (1) to work out design details for a unit that would be interchangeable for walls, roofs, and floors in A-frame or post-and-beam construction, and (2) to establish that the units would safely span 6 feet with a 40-pound-per-square-foot live load. We decided on a 2-foot-wide unit with a 4-inch opening between faces to accept insulation and stiffeners. Because the interior faces of the units were to be exposed as finished paneling, and the sheathing or subflooring faces were not, we used six clear or sound 4-inch-wide boards on the paneling face and four 6-inch-wide lower quality boards on the sheathing faces (fig. 1). The use of two widths and two grades improved the utilization of random width No. 2 and No. 3 Common lumber.

Manufacture

We made 225 units (the number required for our A-frame) from No. 2 and No. 3 Common 4/4-inch red oak lumber kiln-dried to 10-percent moisture content. The paneling was first rough milled from random length, random width lumber to 7/8-inch-thick, 4 3/8-inch-wide, and 70-inch-long cuttings, and the sheathing to 7/8-inch-thick, 6 3/8-inch-wide, and 73-inch-long cuttings. Four-inch-wide cuttings for the paneling admitted sound character marks only, without holes. Six-inch-wide cuttings for subflooring or roof sheathing admitted sound defects and holes up to 1/2 inch in diameter. The rough cuttings were dressed, center-matched, and V-grooved on a molder to 13/16 inch thick. A 1/4-inch tongue-and-groove pattern was machined on all cuttings. Sheathing was double-end-trimmed to 71 3/4 inches so it would overlap the A-frames set on 6-foot centers, and paneling was trimmed to 68 inches to fit between the A-frames.

Waste from rough milling the sheathing and paneling was used to make 4-inch-deep, 23 3/4-inch-long I-beam stiffeners for the units. Top and bottom flanges were tenoned (fig. 2) to form an interlocking tongue between adjacent units. Flange and web dimensions were made equal to simplify manufacture.

The units were assembled in a jig using 1 1/2-inch staples driven by a pneumatic gun to provide gluing pressure for a cold-setting resorcinol resin adhesive. First, one flange of the I-beam was staple-glued to the web in an I-beam assembly jig; then the paneling was clamped in place in a unit assembly jig with the best faces down. Next, the preassembled I-beams (single flange and web) were staple-glued 16 3/8 inches on center to the panel boards from the inner side of the unit so fasteners would not show on the



NO.	DESCRIPTION	REQ'D
1	SHEATHING 13/16 X 6 1/4 X 71 3/4	4
2	PANELLING 13/16 X 4 1/4 X 68	6
3	STIFFENER 2 3/8 X 4 X 23 3/4	5
3a	FLANGE 13/16 X 2 3/8 X 23 3/4	10
3b	WEB 13/16 X 2 3/8 X 23 3/4	5
4	GLUE, RESORCINOL	0.4 LBS
5	STAPLE 7/16 X 1 1/2 X 16 GA.	230

Figure 1.—Plan of combination roof-floor-wall unit, developed by Wood Products Pilot Plant, North Central Forest Experiment Station, U.S. Forest Service, in cooperation with Vocational Technical Institute of Southern Illinois University, design by William W. Rice, drawn by Charles Gaddis. For details of I-beam stiffener (flange and web), see figure 2.

paneled face. Then 4-inch insulation batts were placed between the I-beams, and the top I-beam flange was staple-glued in place. Finally, sheathing deckboards were staple-glued to the upper flange of the beams. Staple heads were exposed on the faces where roofing and finish flooring would cover the units.

The 225 units required 11,607 board feet of No. 2 Common and 351 board feet of No. 3 Common lumber (table 1). This lumber cost $968, and the yield was 64 percent. Labor, adhesive, staples, and insulation cost $672. Thus, total direct costs were $1,640, or $0.607 per square foot, to produce 2,700 square feet of combination roof-floor-wall units.

A-Frame Installation

To minimize weather damage to the interior of the A-frame, the roof units were installed first. Beginning at the first-floor level, units were installed with the tongued edge up. Successive courses of roof units were lifted into position and engaged with the tongues on the units already in place. Each unit weighed about 90 pounds, and they were easily set into place by two men with a rope and hooks. When

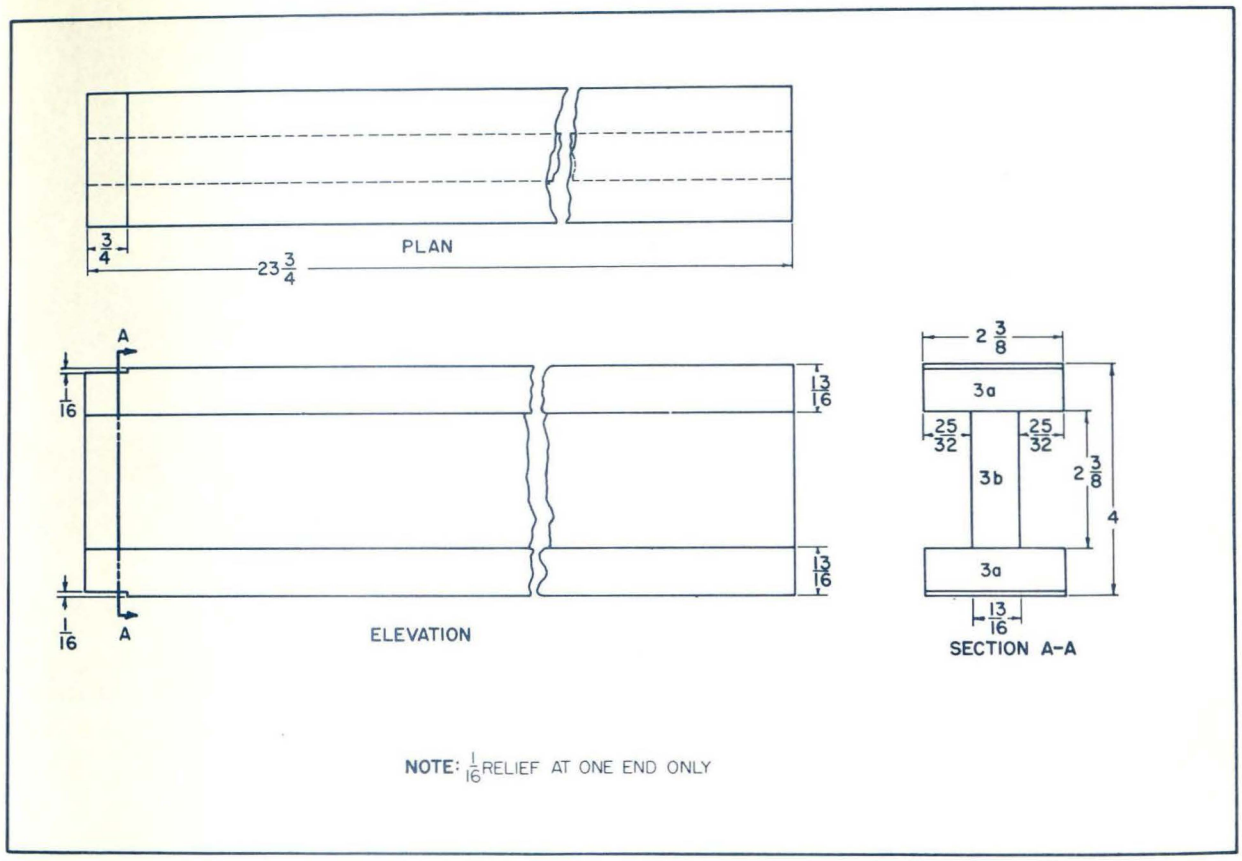


Figure 2.—Detail of I-beam stiffener.

Table 1.—*Prefabrication and installation costs for 225 combination units for an A-frame building, using 4/4 red oak lumber*

Item	Cost (dollars)
Lumber:	
No. 2 Common, 11,607 bd. ft.	940.67
No. 3 Common, 351 bd. ft.	27.13
Adhesive, 27 pounds	27.81
Staples, 2,500	6.00
Insulation, 2,000 sq. ft.	135.00
Labor for milling and assembly	1/ 503.19
Total direct production costs	1,639.80
Installation labor and equipment	1/ 250.80
Total cost	1,890.60
Cost per sq. ft. of unit:	
Before installation	0.607
After installation	0.700

1/ Costs are adjusted to industry wage scales and production levels, and include operation and depreciation of equipment.

a unit was firmly engaged with the one below, the sheathing board ends were nailed to the A-frame beams with a portable pneumatic nailer (fig. 3). Sixteen nails per unit (2 nails per board end) were driven by one man in about 20 seconds.

Floor units were installed in a similar manner (insulation batts were omitted from the second-floor units). At the ridge and where floors butted to the sloping roof, individual panel or sheathing boards (or both) and insulation batts were added to close gaps. Total installation cost for labor and materials was $251. Total installed cost of the panels was $1,891, or $0.70 per square foot of roof and floor area.

Post-and-Beam Installation

For post-and-beam construction, we estimate a wall, roof, or floor unit of the type used, covering 12 square feet, could be installed between wall posts, roof, or floor beams in about 3 man-minutes by two men. If units are installed on roof or floor beams, the sheathing faces of the units constitute the roof sheathing or subflooring, and the panel faces are the

Figure 3.—Installing roof units on A-frame beams with a portable pneumatic nailer.

ceiling paneling (fig. 4). The sheathing face of the units can be papered and shingled as in conventional construction. Strip flooring can be applied directly to the floor units; but parquetry, blocks, or linoleum should have an underlay of hardboard or plywood. The exterior face of wall units could be covered with siding as desired.

Besides the advantages of rapid construction with combination roof and floor units, labor and material is saved in framing. Beams are placed on 6-foot centers compared with the 16-inch centers required with joists or rafters. Walls and ceilings with solid hardwood paneling, if applied over conventional framing, would be prohibitively expensive for many homeowners. But combination units of this type manufactured from No. 2 Common hardwood lumber puts solid hardwood paneling within the reach of most homebuilders.

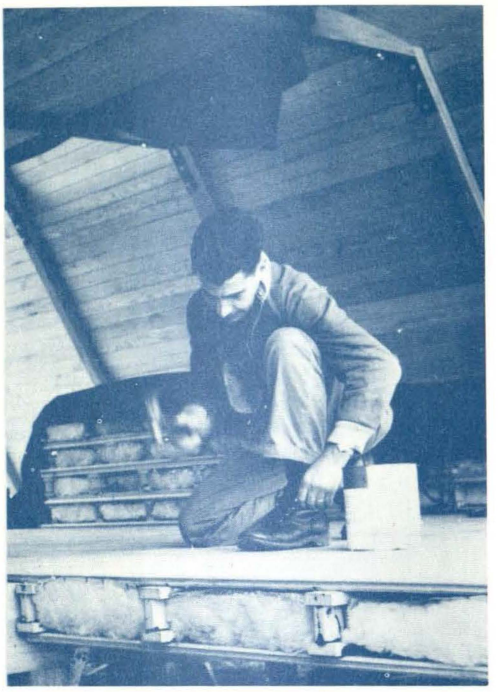


Figure 4.—Combination units. Shows I-beam stiffeners and insulation in place. Visible face is solid red oak paneling.

At $0.70 per square foot of wall or floor, we estimate a prefabricator-contractor team, using combination units, could make and install a conventional post-and-beam or A-frame house shell, including siding and roofing, for about $7 per square foot of floor space. We believe this is less than the usual cost for conventional prefabricated, installed shells with insulated walls and ceilings in a comparable state of completion.

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